Section I. Mortality

Mortality statistics are fundamental for surveillance of public health. Because each death in the U.S. is required by law to be registered with a death certificate, these data provide the most comprehensive source of information available for examining public health outcomes among population subgroups and/or geographic areas. Although the best indicator of population health may be disease incidence (the proportion within a population that are affected by a particular disease or condition), data on disease incidence is difficult to obtain for a number of reasons. All members of the population are not regularly monitored regarding their health status, and may only be diagnosed in an ambulatory setting. Even upon successful diagnosis of disease or condition, this information is not typically collected in a uniform or comprehensive manner and therefore obtaining these data are often difficult and subject to limitations that constrain the degree to which public health outcomes can be estimated from these data. A recent exception is the Healthcare Cost and Utilization Project (HCUP) which provides uniform and relatively complete inpatient hospitalization data for a number of states in the U.S.

While mortality data are generally comprehensive, they are also subject to limitations. The underlying cause of death recorded on the death certificate is dependent on a physician's examination and judgement which may or may not involve a carefully performed autopsy. Potential bias in the recording cause of death codes on death certificates has been suggested in previous studies (Lanska and Peterson, 1995). Among these potential biases are the prevailing norms in the medical community regarding likely causes of death in cases where the underlying cause is vague. Multiple conditions are sometimes present which contribute either directly or indirectly to a person's death. The condition that ends up as the underlying cause of death may be influenced by prevailing norms of the time and the place. If, for example, a person dies of 'natural' causes, their death certificate may indicate an underlying cause of death by heart disease. This is due to the fact that the heart itself has a limited lifetime.

Despite limitations of death certificate data, they continue to be the most comprehensive source of health outcome data available.

A number of recent publications have identified disparities in mortality for small geographic areas in the United States (Pickle *et al*, 1996, Casper *et al*, 2000). This study expands on previous studies by examining a number of causes of death in increased geographic and demographic detail. This analysis focuses specifically on the Appalachian region while allowing mortality comparisons to be made with other parts of the country.

A. Regional Comparisons

Background

This section compares the mortality experience of the Appalachian region with the rest of the United States. This analysis uses the Appalachian Regional Commission's definition of 406 constituent counties as of January 2002. Two basic comparisons are made in this section; one which compares death rates for the Appalachian region and U.S. as a whole, and one which compares Appalachian counties with the rest of the counties in the U.S. Regional disparities are examined along a number of dimensions including cause of death and ethnic/gender/age groups.

Data and Methods

Mortality data

Death certificate data for the years 1990-1997 were obtained through the National Vital Statistics System maintained by the National Center for Health Statistics. The specific causes of death which were analyzed are all-causes, heart disease, cancer(s), cerebrovascular disease (stroke), and chronic obstructive pulmonary disease and allied conditions, diabetes, accidental deaths, deaths from motor vehicle accidents, suicide, and infant mortality. Heart disease, cancer, cerebrovascular, and chronic obstructive pulmonary disease and allied conditions are listed by the Centers for Disease Control and Prevention as the top four causes of death nationally (Anderson and Smith, 2003).

Death certificate data were coded using the International Classification of Disease - 9th revision (ICD-9). Table 1. shows the ICD-9 codes for the causes of death used in this study.

For each decedent, underlying cause of death, age, race, gender, and county of residence at the time of death were abstracted from computerized death certificate files. These death counts were used as the numerators for calculating mortality rates. The study population consisted of black and white men and women who resided in the United States during the period 1990-1997. Each of these sub-groups were divided into two age categories: 35 to 64 and 65 and older. Deaths which occur in the 35 to 64 age-groups are considered premature and preventable.

Population count data for all counties in the U.S., used as denominators in mortality rate calculations, were obtained from the Bureau of the Census for the years 1990-1997. These age, race/ethnicity, and gender-specific intercensal estimates were calculated by the Bureau of the Census through extrapolation of linear trends in population growth and inter-county migration patterns.

Table 1.

Cause of Death	ICD-9 Codes
Heart Disease	391-398, 302, 404-429
All Cancers	140-208
Lung Cancer	162
Colorectal Cancer	153-154, 159.0
Breast Cancer	174
Stroke	430-438
COPD	490-496
Diabetes	250, 357.2,362.01-362.02
Accidental	E800-E999
Motor Vehicle	E810-E825
Suicide	E950-E959

Calculation of Death Rates

Two types of death rates were calculated for each cause-of-death category. First, **age-adjusted** rates of mortality were calculated for the Appalachian region and the rest of the U.S. as a whole, based on the combined deaths and populations counts in each region for eight population subgroups that resided in the U.S. during the period 1990-1997: white men aged 35 to 64, white men aged 65 and older, white women aged 35 to 64, white women aged 65 and older, black men aged 35 to 64, black men aged 65 and older, black women aged 35 to 64, and black women aged 65 and older. Age adjustment is a process that permits the comparison of rates among population groups (e.g., populations defined by race, gender, and geography) who have different age distributions (Anderson and Rosenberg, 1998). For example, age-adjustment allows us to assess whether death rates in two or more counties differed for reasons other than the fact that one county had an older population. Deaths rates for each category were age standardized using the direct method of adjustment with the 2000 U.S. population as the standard. Direct comparisons were made between death rates by ethnic and gender groups both within and between Appalachia and the rest of the U.S. Second, county-level, age-adjusted death rates, were generated for all U.S. counties using a spatial "smoother" based on a *distance weighted, spatial moving average*.* (for complete details see Appendix B.) **Spatial smoothing** is used in this analysis to reduce the statistical variability of county death rates and to compensate for sparse populations and small numbers of deaths for some population subgroups in certain parts of the country. Spatial smoothing involves calculating spatial moving averages of county rates. Using this method, an age-adjusted rate in a single county represents an average of the mortality experience of that county and all of its neighboring counties. In this analysis we have weighted the contribution of neighboring counties by using the distance from the geographic center of each county to those of neighboring counties. A main advantage of spatial smoothing of death rates is that it allows spatial trends in the data to be easily identified.

Regional Disparities

For this section, the county-level death rates are used to make collective comparisons between disparities in mortality among counties in Appalachia and the rest of the counties in the U.S. For each cause of death/demographic subgroup combination, summary statistics were calculated from the distributions of county-level rates for the entire U.S. (excluding Appalachia) and county-level rates for the Appalachia Region. (refer to Section B. County-level Mortality Analyses for details on the generation of county death rates.) For this analysis, we use the ***standard deviation*** of each distribution to assess the level of disparity among counties in that distribution. The standard deviation is a common measure of spread in a distribution. In addition to the standard deviation a number of other summary statistics are provided in tables presented in this report including, the mean, median, range, minimum, maximum, and the number of counties included in the distribution. These statistics allow additional information about the distributions (and the constituent cause of death/demographic subgroup) to be assessed in conjunction with the measure of disparity.

* The spatial moving average used in this analysis was adapted from a method used in two recent publications by the Centers for Disease Control and Prevention and West Virginia University: *Heart Disease in Women: An Atlas of Geographic Disparities* and *Heart Disease in Men: An Atlas of Geographic Disparities.*

1.) Mortality comparisons

Considerable variation in all-cause mortality occurs among demographic subgroups within the U.S. Previous studies have documented fairly distinct geographic patterns in the rates of mortality in the U.S. (Pickle *et al*, 1996, Casper *et al*, 1999). In part, both demographic and geographic variation in rates of mortality reflect underlying differences in social, economic, and environmental conditions that may either directly or indirectly influence individual susceptibility to disease, exposure to hazardous conditions, or ability to obtain appropriate medical treatment.

The death rates for specific causes of death that contribute to the absolute burden of all-cause mortality for both Appalachia and the rest of the U.S. are shown in Figure 1. While both distributions are roughly proportionate to each other, several important differences are worth noting. Relative to the rest of the U.S., Appalachia appears to experience considerable excess of heart disease deaths (651 deaths per 100,000 compared to 585 deaths per 100,000). In addition, Appalachia experiences excess mortality from all cancers (422 to 416), stroke (127 to 123), lung cancer (125 to 117), COPD (101 to 95), diabetes (41 to 37), and motor vehicle accidents (20 to 16).

All-cause death rates for black and white men and women aged 35 to 64 years of age and those aged 65 years and older for the Appalachia region and United States are shown in Figures 2 and 3. All-cause death rates are consistently higher among Appalachian population subgroups compared with U.S. rates, with the exception of black men ages 35 to 64 and black women ages 65 and older. In addition to regional differences, comparison of death rates among population subgroups reveals

Figure 1.

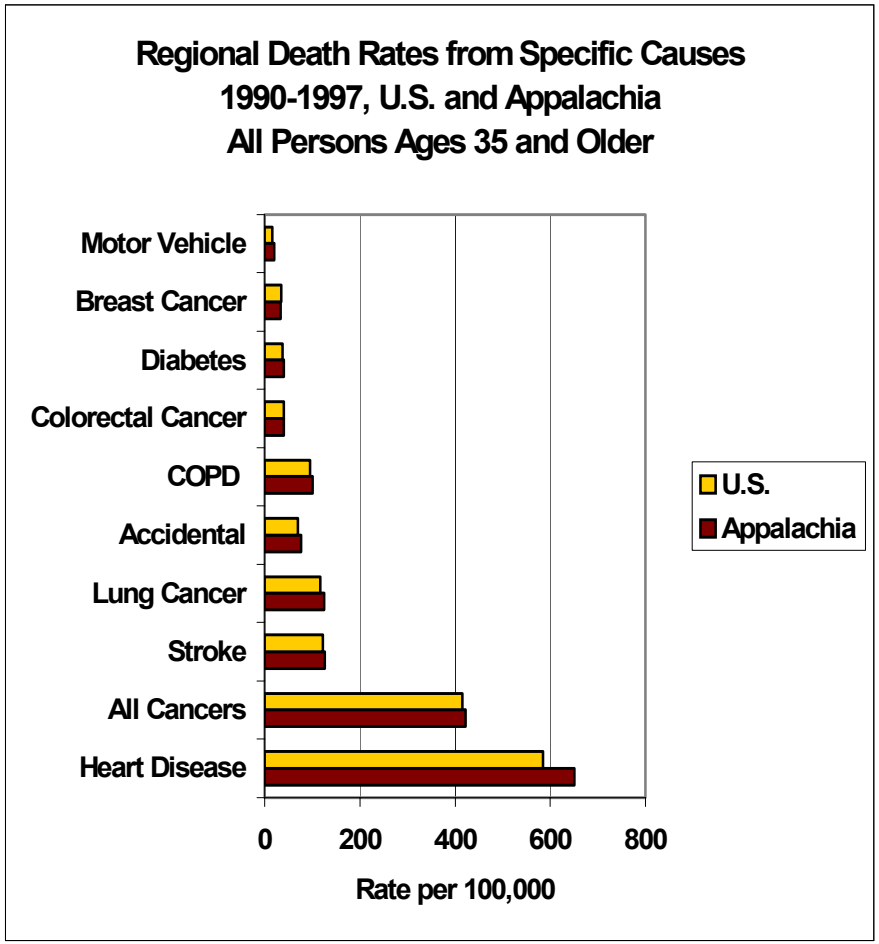


Figure 2.

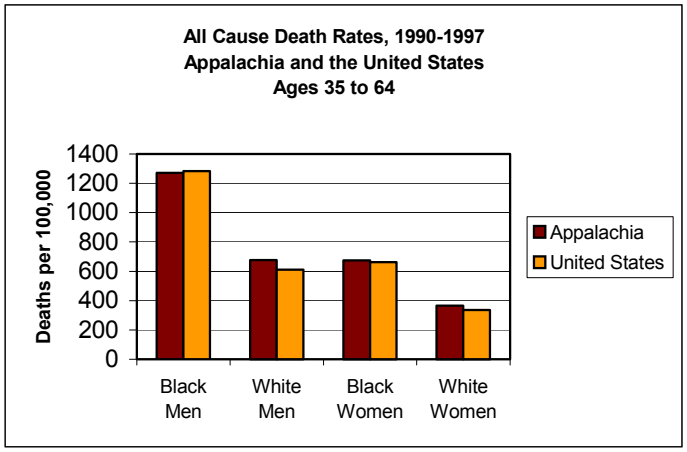
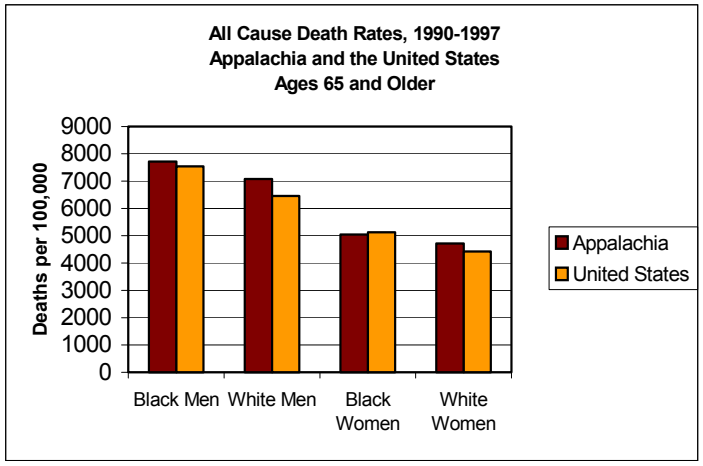


Figure 3.



that black men in both age-groups experience significantly higher rates of mortality than their counterparts in both the U.S. and Appalachia.

Death rates attributable to specific causes for the two age groups used in this study are depicted in Figures 4 and 5. Notably, the highest death rates among persons 35 to 64 are from cancers as opposed to heart disease for persons aged 65 and older. In addition Appalachia suffers from a higher rate of deaths from heart disease and cancers than the U.S. for both age groups. The Appalachian rate of heart disease death among persons ages 35 to 64 was 155 deaths per 100,00 compared to 130 deaths per 100,00 in the non-Appalachian U.S. Heart disease death rates among the elderly were 2144 deaths per 100,00 in Appalachia compared with 1956 deaths per 100,000 in the non-Appalachian U.S. The Appalachian death rate from all cancers among persons ages 35 to 64 was 176 deaths per 100,000 compared to 169 deaths per 100,000 in the non-Appalachian U.S. Cancer death rates among the elderly were 1166 deaths per 100,000 in Appalachian compared with 1162 deaths per 100,000 in the non-Appalachian U.S

According to these data, the Appalachian region suffers higher premature death rates from all causes of death examined in this study with the exception of breast cancer. Among the elderly, the Appalachian region suffers higher rates of mortality for all causes except colorectal cancer and breast cancer.

A comparison of regional deaths rates for each specific cause of death/age group/demographic subgroup are shown in Figures 6 and 7. These graphs also allow quick comparisons to be made regarding the contribution that each cause of death makes to the overall burden of mortality. Figure 6 shows that

heart disease is the leading cause of premature mortality (ages 35 to 64) among black men and white men in both Appalachia and the rest of the U.S. with black men experiencing considerably higher death rates. Cancers, however, appear to be the leading cause of premature mortality among black and white women. Figure 7 shows the region-wide death rates for elderly population subgroups (ages 65 and older). Heart disease is the leading cause of death among elderly white and black men although white elderly men experience considerably higher death rates within Appalachia than outside it. Black men in the U.S. (excluding Appalachia) experience higher heart disease death rates than those within Appalachia. Heart disease is also the leading cause of death among elderly women.

Figure 4.

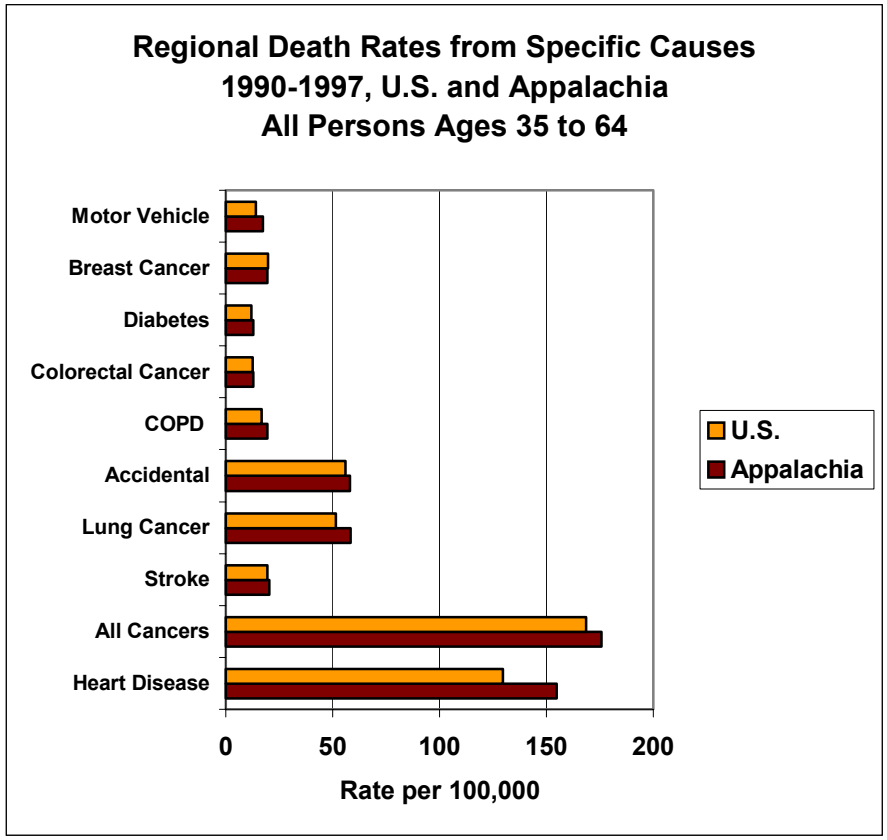


Figure 5.

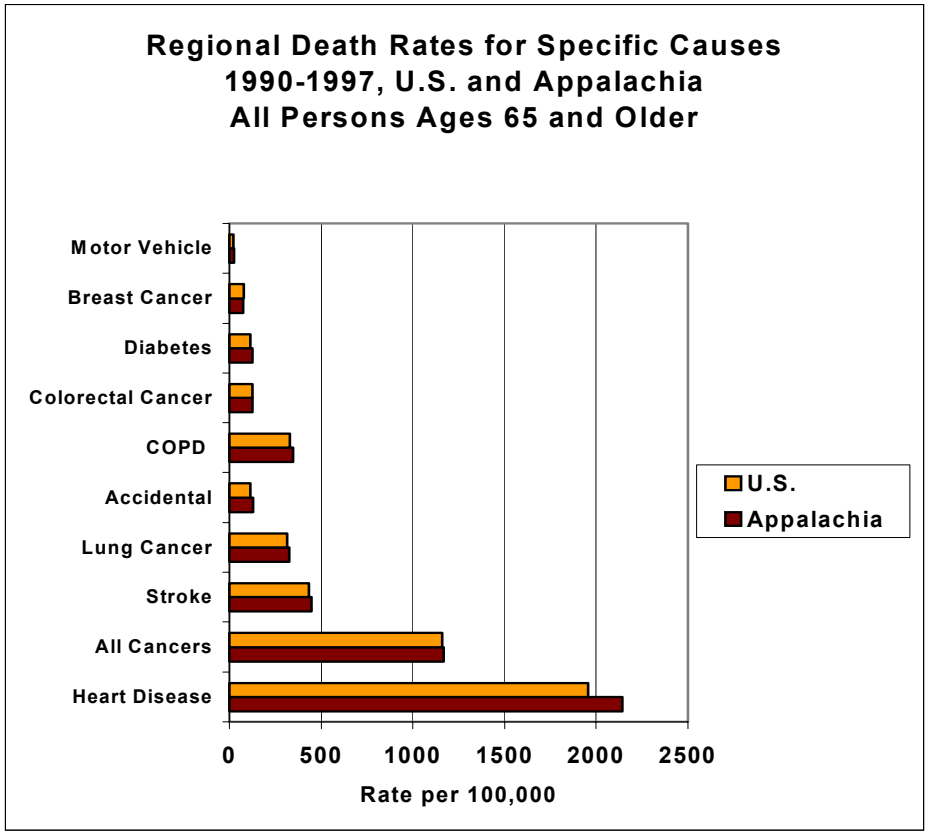


Figure 6. Regional Death Rates from Specific Causes, U.S. and Appalachia, 1990-1997 – Persons Ages 35 to 64

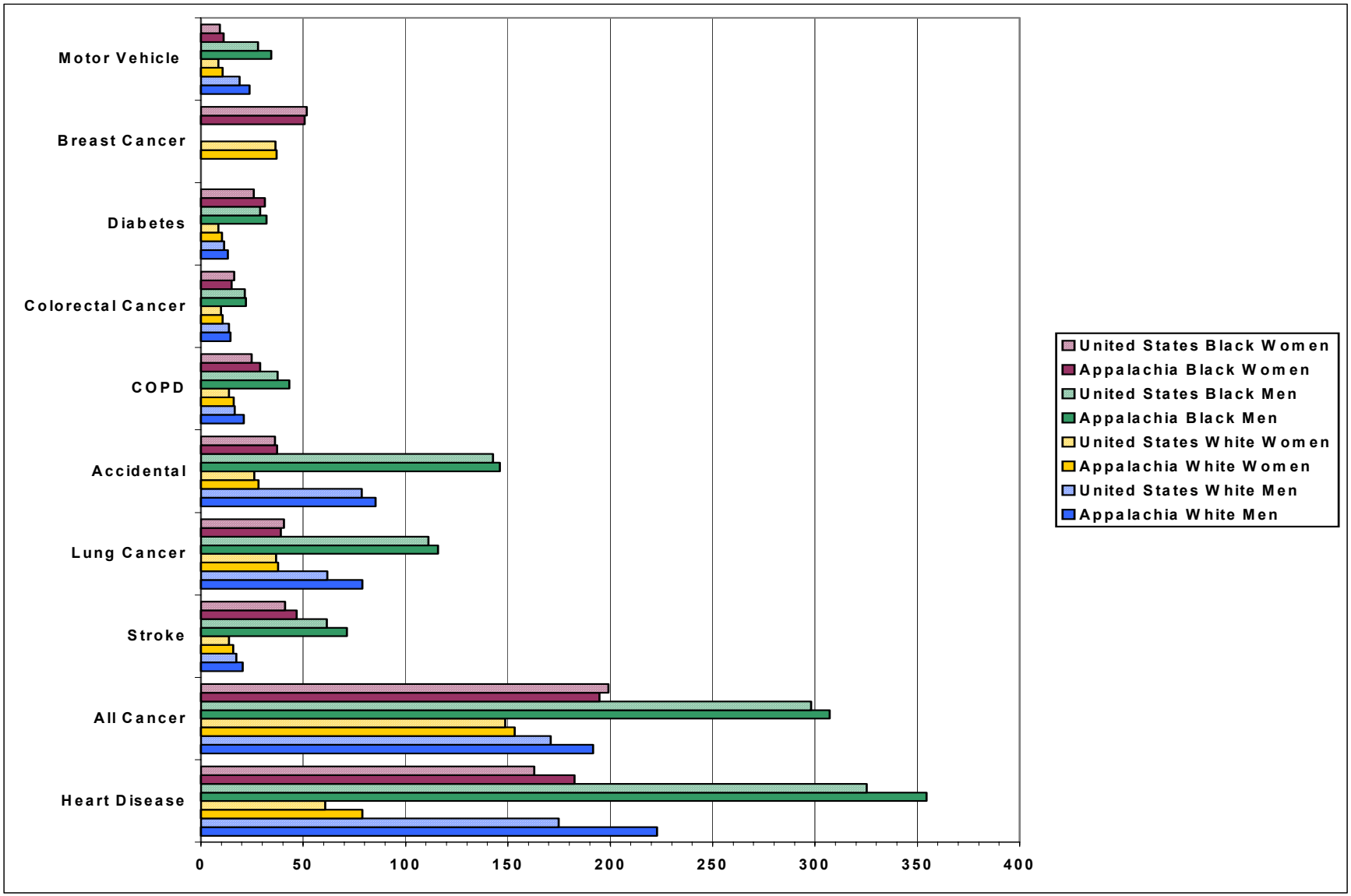
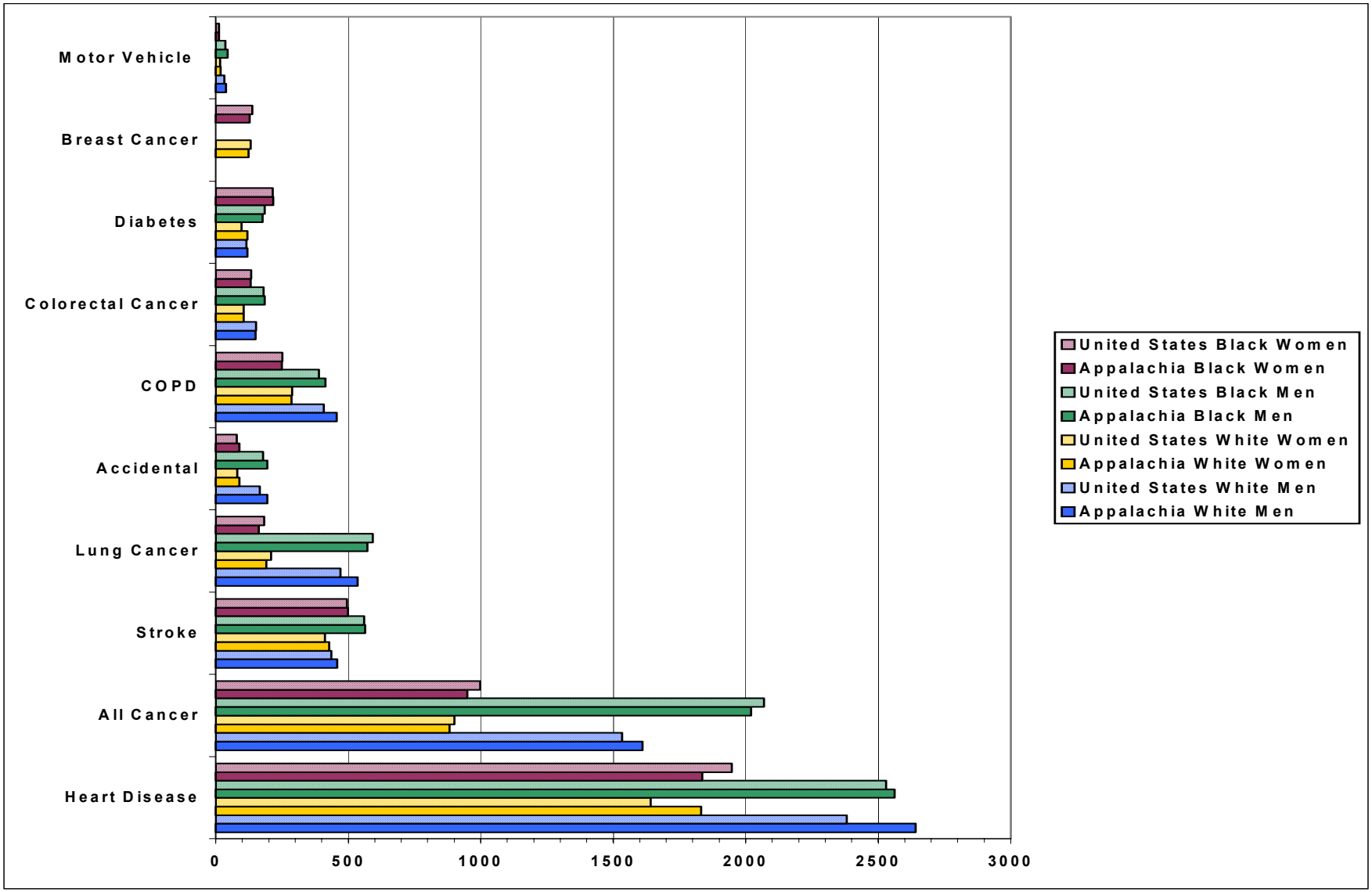


Figure 7. Regional Death Rates from Specific Causes, U.S. and Appalachia, 1990-1997 – Persons Ages 65 and Older



Regional Disparities in County-Level Death Rates

Analyses were conducted for both the United States and Appalachia to determine the cause of death categories that are responsible for the greatest disparities in regional death rates and to identify the population subgroups that suffer the most from these disparities. These results are shown in Tables 2 and 3. County death rates for each cause of death/population subgroup category were ranked based on the value of the standard deviation of their respective county death rate distributions. Table 2 presents data for death rates among persons 35 to 64 years of age and Table 3 presents data for death rates among persons 65 and older. The top ten in each age-group and region are presented. (for complete tables see Appendix C.)

In each table, death rates (represented by the mean, median, range, min, and max) are expressed as deaths per 100,000 population. The number of counties varies due to procedures used to calculate county level death rates. For example, a minimum of 20 deaths is necessary to calculate a county death rate (refer to Section B. County-level Mortality Analyses for details on the generation of county death rates). The standard deviation is a measure of spread in a distribution of values. The higher the standard deviation, the greater the spread between the lowest and highest values (the disparity).

Table 2. Disparities in county deaths rates, 1990-1997, persons ages 35 to 64, ranked by standard deviation, U.S. counties (excluding Appalachia) and Appalachian counties.

United States								
Cause of Death	**Demographic group**	**Standard Deviation**	**Mean**	**Median**	**Range**	**Min**	**Max**	**Number of Counties**
HEART DISEASE	Black Men Ages 35 to 64	73.10	334.44	333	476	143	619	1431
ALL CANCER	Black Men Ages 35 to 64	66.47	306.81	306	876	154	1030	1392
HEART DISEASE	White Men Ages 35 to 64	39.34	186.23	182	241	87	328	2678
HEART DISEASE	Black Women Ages 35 to 64	36.71	170.87	168	298	63	361	1276
ACCIDENTAL	Black Men Ages 35 to 64	35.84	139.64	139	219	52	271	1188
ALL CANCER	White Men Ages 35 to 64	28.72	173.66	101	193	85	278	2676
ALL CANCER	Black Women Ages 35 to 64	26.77	196.02	195	230	110	340	1349
LUNG CANCER	Black Men Ages 35 to 64	23.26	119.66	119	151	54	205	1141
STROKE	Black Men Ages 35 to 64	22.77	70.61	67	125	28	153	923
ACCIDENTAL	White Men Ages 35 to 64	22.38	86.50	85	211	41	252	2653
Appalachia								
Cause of Death	**Demographic group**	**Standard Deviation**	**Mean**	**Median**	**Range**	**Min**	**Max**	**Number of Counties**
HEART DISEASE	Black Men Ages 35 to 64	66.99	358.91	345	348	190	538	267
ALL CANCER	Black Men Ages 35 to 64	46.48	315.30	310	350	128	478	257
HEART DISEASE	White Men Ages 35 to 64	34.06	229.77	225	200	155	355	406
ACCIDENTAL	Black Men Ages 35 to 64	31.29	146.04	145	185	64	249	176
HEART DISEASE	Black Women Ages 35 to 64	31.06	188.40	183	150	122	272	207
ALL CANCER	Black Women Ages 35 to 64	28.96	201.61	198	209	120	329	213
ALL CANCER	White Men Ages 35 to 64	23.56	197.57	195	126	142	268	406
ACCIDENTAL	White Men Ages 35 to 64	21.58	93.53	93	106	49	155	406
STROKE	Black Men Ages 35 to 64	18.21	75.88	74	89	39	128	153
LUNG CANCER	White Men Ages 35 to 64	17.91	83.98	82.5	99	48	147	406

Table 3. Disparities in county deaths rates, 1990-1997, persons ages 65 and older, ranked by standard deviation, U.S. counties (excluding Appalachia) and Appalachian counties.

United States								
Cause of Death	**Demographic group**	**Standard Deviation**	**Mean**	**Median**	**Range**	**Min**	**Max**	**Number of Counties**
HEART DISEASE	Black Men Ages 65 and Older	372.30	2481.09	2479	3223	1057	4280	1594
HEART DISEASE	White Men Ages 65 and Older	298.10	2409.47	2410	1942	1575	3517	2684
HEART DISEASE	Black Women Ages 65 and Older	280.25	1894.16	1878	2567	676	3243	1620
ALL CANCER	Black Men Ages 65 and Older	255.88	2074.14	2083	2399	976	3375	1567
HEART DISEASE	White Women Ages 65 and Older	217.81	1610.21	1620	1469	953	2422	2681
ALL CANCER	White Men Ages 65 and Older	141.18	1551.41	1560	1028	971	1999	2684
ALL CANCER	Black Women Ages 65 and Older	139.11	978.11	966	1206	598	1804	1479
STROKE	Black Men Ages 65 and Older	133.43	626.95	623	994	263	1257	1221
STROKE	Black Women Ages 65 and Older	112.95	553.53	540.5	816	248	1064	1330
LUNG CANCER	Black Men Ages 65 and Older	109.04	619.48	607	700	372	1072	1258
Appalachia								
Cause of Death	**Demographic group**	**Standard Deviation**	**Mean**	**Median**	**Range**	**Min**	**Max**	**Number of Counties**
HEART DISEASE	Black Men Ages 65 and Older	359.23	2630.10	2611	2203	1725	3928	336
ALL CANCER	Black Men Ages 65 and Older	270.85	2032.13	2032	2149	1303	3452	327
HEART DISEASE	Black Women Ages 65 and Older	253.55	1893.72	1887.5	1434	1306	2740	346
HEART DISEASE	White Men Ages 65 and Older	210.83	2641.13	2656.5	1129	2065	3194	406
HEART DISEASE	White Women Ages 65 and Older	177.14	1825.07	1843	903	1408	2311	406
ALL CANCER	Black Women Ages 65 and Older	129.23	977.01	981	855	671	1526	305
STROKE	Black Men Ages 65 and Older	119.65	601.48	605	750	286	1036	181
STROKE	Black Women Ages 65 and Older	103.96	522.04	512	456	308	764	234
ALL CANCER	White Men Ages 65 and Older	90.21	1618.05	1613	515	1357	1872	406
LUNG CANCER	Black Men Ages 65 and Older	87.28	582.41	575	611	360	971	198

B. County-level mortality analyses

Introduction

The purpose of this section is to examine the geographic dimension of county-level disparities in death rates outlined in Section A. Identifying counties which contribute to disparities in mortality (high and low rate counties) will aid in targeting interventions aimed at reducing these disparities. In conjunction with data that describe the socioeconomic and behavioral landscapes of these counties, these analyses are intended to aid in the development of tailored intervention strategies for reducing adverse health outcomes and disparities in Appalachia.

This section presents a series of maps depicting county-level deaths rates for each cause of death and population subgroups outlined in Section A. Mapped data provides a wealth of information regarding the spatial location and configuration of county death rates. The location of high and low rate counties is easily identified in mapped format, as well as the possibility that, for example, these counties tend to 'cluster' in particular areas. Counties which are likely to represent significant clusters of both high and low rates have been identified on each map.

In addition to aggregate death rates, temporal trends were estimated for each county in the Appalachian region over the period 1985-1997. These trends help to identify specific areas that are either effectively preventing/delaying mortality or experiencing adverse conditions which impede effective prevention.

Data and Methods

Mortality data

Death certificate data for the years 1985-1997 were obtained through the National Vital Statistics System maintained by the National Center for Health Statistics. For each decedent, underlying cause of death, age, race, gender, and county of residence at the time of death were abstracted from computerized death certificate files. These death counts were used as the numerators for calculating mortality rates. The study population consisted of black and white men and women who resided in the United States during the period 1985-1997. Each of these subgroups was divided into two age categories: 35 to 64 and 65 and older. Deaths which occur in the 35 to 64 age-groups are considered premature and preventable.

Population count data for all counties in the U.S., used as denominators in mortality rate calculations, were obtained from the Bureau of the Census for the years 1985-1997. These age, ethnic, and gender-specific intercensal estimates were calculated by the Bureau of the Census through extrapolation of linear trends in population growth and inter-county migration patterns.

Calculation of Death Rates

County-level death rates were calculated for each cause of death category. Age-adjusted rates of mortality were calculated for all counties in the contiguous U.S., based on the combined deaths and populations counts in each county for eight population subgroups that resided in the U.S. during the period 1990-1997: white men aged 35 to 64, white men aged 65 and older, white women aged 35 to 64, white women aged 65 and older, black men aged 35 to 64, black men aged 65 and

older, black women aged 35 to 64, and black women aged 65 and older. Deaths rates for each category were standardized using the direct method of standardization, with the 2000 U.S. population as the standard. This section presents data primarily for the Appalachian region with some examples of national distributions. Complete maps of county-level death rates for the coterminous U.S. are provided in Appendix A.

County-level, age-adjusted death rates, were spatially "smoothed" based on a *distance weighted, spatial moving average*. (Refer to Section I. A. *Calculation of Death Rates*, for complete details see Appendix B.) For this section, the county-level death rates have been mapped to enable easy identification of high and low rate counties in the region. To analyze the distribution of rates among Appalachian counties, smoothed county-level death rate distributions were divided into quartiles. Within each distribution, we identified both *low outliers* and *high outliers*. **Outliers** are counties that had statistically unusually low or high rates relative to the majority of counties. Low outliers were identified as counties with death rates lower than the 25^{th} percentile minus 1.5 times the interquartile range (25^{th}-75^{th} percentile), and high outliers were identified as counties with death rates higher then the 75^{th} percentile plus 1.5 times the interquartile range. The distributions for all population subgroups for each cause of death were mapped and analyzed. The identification of outliers allows a quick visual assessment of the counties in Appalachia most likely to represent clusters of high and low rate areas. * On each of the maps, the darker shades represent higher death rates.

For the calculation of county-level death rates a minimum of 20 deaths were required to generate a reliable rate. In many cases, particularly for death rates by ethnicity, a large number of counties did not meet the minimum criteria despite the aggregation of data from neighboring counties. In these cases counties have been labeled as ***Insufficient Data***.

Deaths attributable to suicide are relatively rare. Over the period of analysis in this study, the number of suicide deaths was too small to permit the calculation of death rate by age, race/ethnicity, and gender at the county level. Death rates for suicide were therefore calculated for six demographic subgroups; all persons, all men, and all women ages 35 to 64 and ages 65 and older.

Infant mortality rates were taken directly from the Area Resource File (ARF) and were calculated as a 5-year average over the period 1993-1997.These mortality rates were generated for white population and non-white population.

Temporal trends

County-level temporal trends were estimated over the period 1985-1997. Due to small numbers of deaths on an annual basis for individual counties, a three-year running average was used to generate age-adjusted rates of mortality over the period 1985-1997 for each Appalachian county. To quantify mortality trends over the study period, linear regression models were fitted to log-transformed mortality rates for each county using the following model:

$$y = \alpha + \beta(x) + \varepsilon$$

where y= ln(age-adjusted rate), x=year, e=error term, and $100(\varepsilon^{\beta} - 1)$ = ***the average percent change*** in mortality for each three-year average.** Due to temporal variability in the number of deaths in any given 3-year period. We were unable to calculate a rate for each period (minimum of 20 deaths required). To ensure the trend was calculated for an acceptable number of estimates, we limited the calculation of trends to

those counties for which there were a minimum of seven estimates of the possible thirteen over the period 1985-1997. To ensure the trends represented contemporary conditions, an additional constraint required that at least four of the seven estimates occurred after 1990. In many cases these limitations prevented the estimation of county-level temporal trends. For presentation, the distribution of trend values was categorized into 6 classes: strong decline (4.9 or greater average percent decline), moderate decline (1.9 to 4.9 average percent decline), negligible change (0.9 average percent decline to 0.0 average percent increase), moderate increase (1.0-4.9 average percent increase), strong increase (4.9 or greater average percent increase) and insufficient data (Barnett and Halverson, 2001).

A Cautionary Note

The maps presented here provide a powerful representation of the distribution of deaths rates among Appalachian counties. However, because each of the distributions is divided into quartiles regardless of the range of mortality rates, care must be taken when evaluating the relative importance of each distribution. The maps are not directly comparable between causes of death, and it is important to examine the values in each quartile for all maps. Some guidance in the interpretation of the overall mortality burden that is represented by each cause of death is provided in Section A. (Figures 6-7 and Tables 2-3).

* An alternative method for evaluating county-level distributions of death rates was evaluated. This method relied on Local Indicators of Spatial Association (LISA statistics), to measure the degree of spatial clustering among counties. (Anselin, 1995) While promising, the irregular nature of the region and the existence of counties with "insufficient data" resulted in some spurious results and made interpretation difficult.

** The use of a log-linear model allows a comparison to be made of the relative changes in mortality over time for populations in each Appalachian county. Linear regression of log-transformed rates assumes constant proportional change over time rather than constant absolute change over time. This approach has been shown to be a more appropriate model for examining temporal trends in mortality and particularly in making comparison between groups with markedly differing absolute rates. (Kleinman, 1986)

C. Summary

The Appalachian region, as a whole, experiences excess in mortality for a number of causes when compared to the non-Appalachian U.S. Among the causes of death examined in this study, Appalachian populations suffer the most significant excesses in heart disease mortality.

There are, however, considerable differences in the burden of mortality among age/gender/ethnic groups. Younger black men (ages 35 to 64) experience considerably higher deaths rates for the major causes of death (heart disease, cancers, stroke, lung cancer, and accidental) than either black women or white men and women of comparable age. In addition, the greatest disparities (differences in county rates) in the major causes of death occur among populations of black men of both age groups examined in this study.

County-level analyses reveal a highly variable landscape of mortality within both the Appalachian region and the non-Appalachian U.S. In many cases, distinct gradients exist with the central and southern portion of the region experiencing more adverse conditions than those in the northern part of the region. Death rates from all causes provide a cumulative measure of the burden of mortality. The maps shown on pages 22 to 25 suggest, for the most part, general north-south gradients in the burden of mortality in Appalachia with the central and southern portions experiencing more adverse mortality outcomes.

However for some causes of death (and age/gender/ethnic groups) this gradient is reversed, with the northern portion of the region experiencing more adverse conditions than either the central or southern parts of the region. Examples of this type of gradient include death rates from cancer for elderly women, breast and colorectal cancers, lung cancer among elderly women, and diabetes.

Analyses of county-level death rates for the conterminous U.S. has revealed large clusters of high death rate counties in the Appalachian region which represent the largest such clusters in the country. Among specific causes of death, which exhibit large clusters of high death rate counties in the Appalachian region, some of the most notable exist for heart disease, all cancers, lung cancer, COPD, and diabetes.

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